U. S. COAST GUARD AIREYE REMOTE SENSING SYSTEM:
THE SYSTEM-ITS USES-FUTURE UPGRADES

CWO2 Brad T. Smith
U.S. Coast Guard
Washington, DC.

ABSTRACT

This paper will discuss the U.S. Coast Guard's Aireye remote sensor system, its uses and future upgrades. The Aireye system is a remote sensor package integrated into the HU-25B aircraft stationed at U.S. Coast Guard Air Station Cape Cod.

The system consists of a Side Looking Airborne Radar (SLAR), an Infrared/Ultraviolet line scanner (IR/UV), and a high resolution reconnaissance camera. The system is integrated into a sensor management and display system.

BACKGROUND

In the Mid 1970's, the U.S. Coast Guard realized it had no long-range airborne sensor system that could detect, identify, and document an oil spill and its out flow.

The Coast Guard decided to equip its HU-25A Medium Range Surveillance (MRS) aircraft with an AIREYE sensor package. This decision to integrate a remote sensor system into the

new MRS aircraft would improve the Coast Guard's ability to carry out its maritime missions much more efficiently.

Without the AIREYE system, a 4 hour oil surveillance mission -in good visibility conditions- would cover approximately 3,500 sq. nautical miles of area.

This area covered is quite insignificant when compared to the 2 million sq. naut. mi. of U.S. coastal zone the Coast Guard is required to monitor. With an AIREYE equipped aircraft, now over 70,000 sq. naut. mi. of area could be covered in the same 4 hour mission.

Other missions of the Aireye system include:

- o Enforcement of Laws and Treaties
- o Search and Rescue
- o International Ice Patrol

AIREYE Detailed Block Diagram

INTRODUCTION

The current AIREYE system is an airborne day/night all weather multi-sensor system consisting of a Side-Looking-Airborne-Radar (SLAR), an Infrared/Ultraviolet (IR/UV) line scanner, and a KS-87B reconnaissance camera.

These are all integrated into a real-time digital sensor data management and display system.

The Aireye system at one time included an Active-Gated-Television (AGTV), however this sensor was removed as it was a proof of concept system only.

The system consists of the following components:

- o Receiver/Transmitter
- o Synchronizer
- o Control Head
- o Antenna
- o Power Supply
- o Recorder/Viewer

The SLAR system works similar to other radar systems in that it transmits a short burst of radio energy, the energy strikes an object and returns to a receiver, and is displayed on a screen.

REMOTE SENSORS

SLAR: The Primary sensor used in the Aireye system is the Side Looking Airborne Radar (SLAR). The SLAR system is an X band Radar capable of producing detailed maps up to 80 miles on either side of the aircraft. The system was manufactured by Motorola and is designated the AN/APS-131.

The SLAR system works on the principle that oil film reduces the sea surface roughness (gravity waves), which in turn, reduces the radar reflectivity of the surface so that the radar signal reflected representing the oil covered areas is less than that reflected from the normal sea surface.

This absence of return from the oil covered areas is then displayed on either the Multi Purpose Display (MPD) or the Recorder/Viewer system.

In the APS-131 side looking radar system the radar antenna is a dual element antenna designed to have wide coverage in the elevation plane, but the narrowest possible coverage in the azimuth plane.

Infrared/Ultraviolet IR/UV Line scanner: The Infrared system works on the principle that any object on the earth's surface is a source of infrared energy, which is energy generated by molecular motion within an object. Oil radiates energy differently than water, and because of this property oil covered water can be differentiated from clean water.

The Ultraviolet system operates on the principal that Ultraviolet wavelengths are reflected off oil covered water differently than clean water. The system differentiates this change between clean and oil covered water and displays it on a monitor.

The Texas Instruments RS-18C IR/UV line scanner passively detects IR/UV energy radiated by frequency differentiated features along the aircraft flight path. The IR/UV line scanner processes the IR/UV energy detected and provides an analog output suitable for video recording or display.

The scanner scans across an area under and to the sides of the aircraft flight path and detects IR/UV energy on three channels (two IR and one UV). The signals detected are passed to a power supply which provides synchronous and video processing, and power distribution throughout the system. The line scanner interfaces directly with the control/display subsystem of the Aireye by providing video, synchronous, and status signals to the Display Interface Unit (DIU).

Reconnaissance Camera: The KS-87B is a high resolution, 5 inch format camera system. Its combination of high cycle rate, interchangeable high resolution lens cones, and large film capacity have made it a principal aerial reconnaissance camera.

The KS-87B system can be used in a 90 degree mapping mode or a 30 degree oblique mode used for documentation of vessel names and hull number at a stand off distance. The camera system incorporates an Auxiliary Data Annotation System (ADAS) to expose onto the film pertinent information ie. Lat/Long, Time, Date... A complete range of shutter speeds are available from 1/60 to 1/3000 second. All functions are completely automated, including shutter speed, film advance, annotation, and aperture.

The camera system consists of two cassettes, a magazine, camera body, four interchangeable lens cones, and a light sensor.

DATA MANAGEMENT SYSTEM

Management of the vast amount of sensor data and coupling of this data to the operator is provided by the AIREYE real-time processing, display and recording sub-system. The capabilities of this system includes:

- o Real-time geometrically corrected display of all sensor data with operator selectable formats and complete annotation.
- o Onboard hard copy of all sensor data with complete annotation of position and aircraft data.
- o Integrated system controls with system function selectable by a single control and display unit using a structured menu selection.
- o Real-time digital image processing of sensor data scaling, image sharpening and image smoothing.
- o Integrated map display functions providing integration of sensor and aircraft navigation data.
- o Continuous video tape record of annotated data with capability to enhance video tape data.

OPERATIONAL OVERVIEW

The major Aireye processing units are (1) the ROLM 1602B Sensor computer, (2) the CV-3721/ASD-6 Signal Data Converter or Scan Converter, and (3) the CV-3722/ASD-6 Signal Data Converter or Display Interface Unit (DIU).

The DIU accepts analog video and synchronization signals from the SLAR, IR/UV line scanner and video tape unit. This data is converted to a digital format in the DIU and transferred to the Scan converter for formatting for real time display, recording or subsequent digital enhancement processing.

The DIU and Scan Converter are normally controlled by the Aireye operating program resident in the Rolm 1602B Sensor computer.

Operator control of program and system functions is facilitated by a menu driven Control and Display Unit (CDU) coupled to the Rolm computer using one of two system 1553 interfaces. In the event of a Rolm computer failure, DIU and Scan Converter functions may be controlled by a degraded mode control unit which provides limited system functions adequate to allow the completion of a mission.

Sensor Computer The Sensor computer is the Rolm 1602B military specification computer designed for severe environment and high reliability applications. The Sensor computer preprocesses annotation, vector, map, cursor, SLAR geometric correction, and image enhancement data and provides the appropriate parameters, commands and control for these functions to be implemented within the Scan Converter.

The Sensor computer can perform a ship count function on selected video acquired from the Scan Converter frame memory. It also serves as the data collection and reporting point for Built In Test Equipment (BITE) fault status.

The Sensor computer executes programs as either a background task or a foreground interrupt task. Rapid processing is

mandatory to effect image enhancement processing within mission operations.

The basic CPU contains 16K of core memory, with an expansion capability to 64K of a mix of core, RAM or ROM. The input/output (I/O) section of the CPU facilitates data transfer to and from the CPU and contains the following interfaces: RNAV ARINC 582 data bus, RNAV MIL-STD-1553 data bus, inertial navigation sensor ARINC 571 data bus, radio altimeter analog data signals, CDU control via the MIL-STD-1553 data bus, digital magnetic tape controller, a display interface between the Scan Converter and Sensor computer, an annotation interface providing data transfer and command to the ADAS system and an I/O buffer that controls the flow of signals to and from the CPU at a relatively low speed.

Scan Converter: The Scan Converter is a microprocessor controlled unit that in conjunction with the Sensor computer and the DIU is used perform image enhancements in less than 2 seconds.

The Scan Converter subsystem features microprocessor control and random access refresh memory to store the equivalent of five complete frames of video data from the IR/UV line scanner, SLAR, VTR and graphics annotation. Microprocessors are used to control the following Scan Converter functions:

- o Convert SLAR, IR/UV sensor data to real-time falling raster display on the Multi Purpose Display (MPD).
- o Processes the images selected from all sensor data recorded in the Scan Converter freeze frame memory to enhance them.
- o Stores and formats map functions, vectors, and image and mission mode annotation data for display on the MPD.
- o Controls the cursors interactively by trackball, including the zoom-frame cursor.

o Provides switching to select for viewing on the MPD, video signals originating at the SLAR or IR/UV sensors.

The Scan Converter provides several image enhancement signal processing algorithms which may be selected and interactively used by the sensor operator. These image enhancement algorithms include: intensity scaling/contrast enhancement, frame to frame averaging, zoom, and spatial filtering.

The sensor operator controls each enhancements by use of the Control Display Unit (CDU) and the trackball. The sensor operator is prompted at the CDU by messages from the computer. The CDU transfers command and control data to the computer, while the Scan Converter actually performs the detailed computations.

four full 512 X 512 frames of video (approximately 1 megabyte). The second is an auxiliary refresh memory which has the capacity to store 256K bytes of data (1 frame of video) and is used as a scratch pad for processing and enhancing the images from the frame memory to the MPD screen.

The processed data is converted to an analog video signal in the DAC circuitry for display on the MPD.

Display Interface Unit (DIU): The DIU converts SLAR and IR/UV line scanner data into a geometrically corrected digital format signal for display on the MPD, interfaces the digitized, integrated SLAR and IR/UV sensor data with the Scan Converter, and provides for degraded display mode operation.

If the sensor computer should fail, the degraded mode control circuitry of the DIU will provide data transfer and formatting of the SLAR, IR/UV and manual aircraft data to the Scan Converter. Display commands are inputted from the Aireye degraded mode control panel and are used to control specific hardware functions along with the degraded mode and Scan Converter microprocessor programs.

DIU Interface. The DIU provides two channels for transmitting data between itself and the Scan Converter. One channel is a unidirectional 8 bit bus for sensor data. The other is a bidirectional bus that is used for command and control status.

The interface sensor data acquisition section processes two types of sensor data SLAR and IR/UV. The digitized TV data is passed directly through the interface to the refresh memory video input port if freeze frame is requested.

Data input from either the SLAR or the IR/UV require buffering by the memory included in the interface. When acquiring SLAR data the memory is configured as two sections which are used to store data from the left and right side antenna transmissions. The memory is loaded on

Digitized video from the DIU is sent to the Scan Converter. The video processor executes the image enhancement processing and provides the graphics, alphanumeric, and cursor map generation and target and data annotation.

The memory of the Scan Converter is divided into two sections. The first is a frame memory which has the capacity to store

demand at a rate determined by the velocity of the aircraft and is accessed as required, by the Scan Converter for entry in the refresh memory.

When acquiring IR/UV line scanner data the memory is organized as three independent memories which function as a triple buffer. During each scan, data from three detectors is loaded in two of the memories while the third is available for access by the Scan Converter. On command the memories are swapped at a rate determined by the velocity and altitude of the aircraft with the oldest line of data previously acquired available for display processing.

FUTURE UPGRADES

The U.S. Coast Guard Aireye system has responded time and again to mapping and tracking of major oil spills throughout the world. Just recently, U.S. Coast Guard Air Station Cape Cod responded to the Arabian Gulf oil spill during Operation Desert Storm.

During the past 5 years the Coast Guard has realized just how important the Aireye sensor system is to understanding the movement and predicting areas of impact of major oil spills. In realizing this fact, the Coast Guard also recognized the Aireye system needed an upgrade to replace its aging and soon to be unsupportable SLAR system.

The upgrade to the SLAR system would include the following:

- o Capability to downlink an image (IR/UV, SLAR,) that can be geo-referenced to allow scaling and overlaying on the National Oceanic and Atmospheric Administration (NOAA) geographic information system data base.

- o Replacement of the existing

Recorder/Viewer and Synchronizer with a signal processor, image processor, mission data recorder, and a high resolution display monitor.

- o Addition of a high resolution digital still camera system.

- o Replacement of the existing control heads with a one central control that can be integrated through a PC, and accessed by a standard QWERTY keyboard.

SUMMARY

Past experiences in the Marine Environmental Protection (MEP) arena have shown there is, and will continue to be, a need for a large scale, long range remote sensing platform to assist in mapping and prediction of oil spill movement. The Aireye remote sensor system currently fulfills this need, and can continue to in the future with upgrades to the existing system. This paper has described the current Aireye system, its uses, and hopeful upgrades in the future.

REFERENCES

- (1) U.S. Coast Guard Air Station Cape Cod Aireye Information Manual.
- (2) Technical Order T.O.12P3-7APS131-2 U.S. Army.